Please check the examination details below before entering your candidate information

| Candidate surname | StemUp Model Solution | Other names |
|---|---|---|

**Pearson Edexcel**
**International**
**Advanced Level**

| Centre Number | Candidate Number |
|---|---|
| | |

# Monday 24 June 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **WFM03/01**

# Mathematics

## International Advanced Subsidiary/Advanced Level
## Further Pure Mathematics F3

**You must have:**
Mathematical Formulae and Statistical Tables (Blue), calculator

Total Marks

**Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

## Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

## Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

## Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

*Turn over* ▶

P56480A

©2019 Pearson Education Ltd.

1/1/1/1/

P 5 6 4 8 0 A 0 1 3 2

Pearson

stemup.co.uk

Leave blank

**Answer ALL questions. Write your answers in the spaces provided.**

**1.** A hyperbola $H$ has equation

$$\frac{x^2}{a^2} - \frac{y^2}{9} = 1 \qquad \text{where } a \text{ is a positive constant}$$

The foci of $H$ are at the points with coordinates (6, 0) and (–6, 0)

Find

(a) the exact value of the constant $a$,

**(3)**

(b) the equations of the directrices of $H$.

**(3)**

(a) $ae = 6$ and $b^2 = a^2(e^2 - 1) \Rightarrow a^2(e^2 - 1) = 9$

$a^2e^2 - a^2 = 9$

$36 - a^2 = 9$

$a^2 = 27$

$a = \sqrt{27} = 3\sqrt{3}$

(b) $e = \frac{6}{a} = \frac{6}{3\sqrt{3}} = \frac{2}{\sqrt{3}}$ (check: $e^2 - 1 = \frac{4}{3} - 1 = \frac{9}{27}$ ✓)

Directrices: $x = \pm \frac{a}{e} = \pm 3\sqrt{3} \times \frac{\sqrt{3}}{2} = \pm \frac{9}{2}$

$x = \frac{9}{2}$ and $x = -\frac{9}{2}$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 1 continued**

**Q1**

**(Total 6 marks)**

Leave blank

**2.** (a) Starting from the definitions of $\sinh x$ and $\cosh x$ in terms of exponentials, prove that

(i) $\cosh 2x \equiv 2\cosh^2 x - 1$

(ii) $\sinh 2x \equiv 2\sinh x \cosh x$

**(4)**

(b) Solve the equation

$$\cosh 2x - 7\cosh x = -7$$

giving your answers as exact logarithms.

**(5)**

(a)(i) $RHS = 2\cosh^2 x - 1 = 2 \times \frac{(e^x + e^{-x})^2}{4} - 1$

$= \frac{2(e^{2x} + 2e^x e^{-x} + e^{-2x})}{4} - 1 = \frac{e^{2x} + 2 + e^{-2x}}{2} - 1$

$= \frac{e^{2x} + e^{-2x}}{2} + 1 - 1 = \frac{e^{2x} + e^{-2x}}{2}$

$= \cosh 2x = LHS \quad \therefore \cosh 2x \equiv 2\cosh^2 x - 1$

(ii) $RHS = 2\sinh x \cosh x = 2 \times \frac{e^x - e^{-x}}{2} \times \frac{e^x + e^{-x}}{2}$

$= \frac{2(e^{2x} - e^{-2x})}{4} = \frac{e^{2x} - e^{-2x}}{2}$

$= \sinh 2x = LHS \quad \therefore \sinh 2x \equiv 2\sinh x \cosh x$

(b) $\cosh 2x - 7\cosh x = -7$

$2\cosh^2 x - 1 - 7\cosh x + 7 = 0$

$2\cosh^2 x - 7\cosh x + 6 = 0$

$(2\cosh x - 3)(\cosh x - 2) = 0$

$\cosh x = \frac{3}{2}$ or $\cosh x = 2$

$\cosh x = \frac{3}{2} \Rightarrow x = \pm \ln\left(\frac{3}{2} + \sqrt{\left(\frac{9}{4} - 1\right)}\right) = \pm \ln\left(\frac{3}{2} + \frac{\sqrt{5}}{2}\right)$

$\cosh x = 2 \Rightarrow x = \pm \ln(2 + \sqrt{(4 - 1)}) = \pm \ln(2 + \sqrt{3})$

$x = \ln\left(\frac{3 + \sqrt{5}}{2}\right), \quad x = -\ln\left(\frac{3 + \sqrt{5}}{2}\right), \quad x = \ln(2 + \sqrt{3}), \quad x = -\ln(2 + \sqrt{3})$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 2 continued**

Leave blank

**Question 2 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 2 continued**

**Q2**

**(Total 9 marks)**





stemup.co.uk

Leave blank

**3.** Find

(a) $\int \frac{1}{8 + 4x + x^2} \, dx$

**(3)**

(b) $\int \frac{1}{\sqrt{(8 - 4x - x^2)}} \, dx$

**(4)**

(a) $8 + 4x + x^2 = (x + 2)^2 + 4$

$\int \frac{1}{8 + 4x + x^2} \, dx = \int \frac{1}{(x + 2)^2 + 2^2} \, dx$

$= \frac{1}{2} \arctan\left(\frac{x + 2}{2}\right) + c$

(b) $8 - 4x - x^2 = 12 - (x^2 + 4x + 4) = 12 - (x + 2)^2$

$\int \frac{1}{\sqrt{(8 - 4x - x^2)}} \, dx = \int \frac{1}{\sqrt{(12 - (x + 2)^2)}} \, dx$

$= \arcsin\left(\frac{x + 2}{\sqrt{12}}\right) + c = \arcsin\left(\frac{x + 2}{2\sqrt{3}}\right) + c$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 3 continued**

Leave blank

**Question 3 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 3 continued**

**Q3**

**(Total 7 marks)**





stemup.co.uk

Leave blank

**4.**

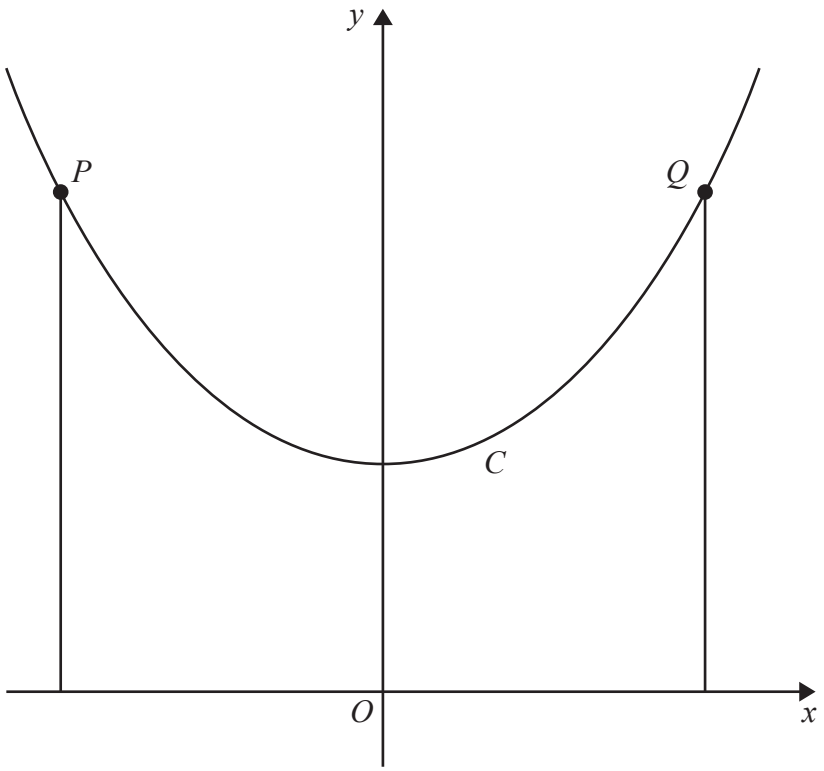



**Figure 1**

Figure 1 shows part of the curve $C$ with equation

$$y = 3\cosh\left(\frac{x}{3}\right)$$

The point $P$ and the point $Q$ lie on the curve. The point $P$ has $x$ coordinate $-3a$ and the point $Q$ has $x$ coordinate $3a$.

(a) Find the length of the arc $PQ$, giving your answer as a multiple of $\sinh a$.

**(5)**

Given that the length of the arc $PQ$ is 12

(b) show that the $x$ coordinate of $Q$ is $3\ln\left(p + \sqrt{q}\right)$, where $p$ and $q$ are integers to be found,

**(2)**

(c) show that the $y$ coordinate of $Q$ is $r\sqrt{s}$ where $r$ and $s$ are integers to be found.

**(2)**

(a) $y = 3\cosh\left(\frac{x}{3}\right) \Rightarrow \frac{dy}{dx} = \sinh\left(\frac{x}{3}\right)$

$$s = \int_{-3a}^{3a} \sqrt{1 + \left(\frac{dy}{dx}\right)^2}\, dx = \int_{-3a}^{3a} \sqrt{1 + \sinh^2\left(\frac{x}{3}\right)}\, dx$$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 4 continued**

$= \int_{-3a}^{3a} \cosh\left(\frac{x}{3}\right) dx = \left[ 3\sinh\left(\frac{x}{3}\right) \right]_{-3a}^{3a}$

$= 3(\sinh a - \sinh(-a)) = 3(\sinh a + \sinh a)$

Arc length $PQ = 6\sinh a$

(b) $6\sinh a = 12 \Rightarrow \sinh a = 2$

$a = \operatorname{arsinh} 2 = \ln(2 + \sqrt{(2^2 + 1)}) = \ln(2 + \sqrt{5})$

$x_Q = 3a = 3\ln(2 + \sqrt{5})$ $\quad (p = 2, q = 5)$

(c) $y_Q = 3\cosh a = 3\sqrt{(1 + \sinh^2 a)}$

$= 3\sqrt{(1 + 2^2)} = 3\sqrt{5}$

y coordinate of Q is $3\sqrt{5}$ $\quad (r = 3, s = 5)$

Leave blank

**Question 4 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 4 continued**

**Q4**

**(Total 9 marks)**





stemup.co.uk

Leave blank

**5.** The plane $\Pi$ has equation

$$\mathbf{r} = \begin{pmatrix} 4 \\ 2 \\ 1 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ 0 \\ 2 \end{pmatrix} + \mu \begin{pmatrix} 2 \\ 1 \\ 3 \end{pmatrix}$$

where $\lambda$ and $\mu$ are scalar parameters.

(a) Find a vector perpendicular to $\Pi$

**(2)**

The line $l$ passes through the point $A$ with coordinates (2, –4, 0) and meets $\Pi$ at the point with coordinates (3, 2, –1).

The acute angle between the plane $\Pi$ and the line $l$ is $\alpha$.

(b) Find $\alpha$, giving your answer to the nearest degree.

**(4)**

(c) Find the perpendicular distance from $A$ to $\Pi$

**(4)**

(a) $n = (i + 2k) \times (2i + j + 3k) = \begin{vmatrix} i & j & k \\ 1 & 0 & 2 \\ 2 & 1 & 3 \end{vmatrix}$

$= i(0 - 2) - j(3 - 4) + k(1 - 0)$

$n = -2i + j + k$

(b) direction of $l$: $\begin{pmatrix} 3 \\ 2 \\ -1 \end{pmatrix} - \begin{pmatrix} 2 \\ -4 \\ 0 \end{pmatrix} = \begin{pmatrix} 1 \\ 6 \\ -1 \end{pmatrix}$

$(i + 6j - k) \cdot (-2i + j + k) = -2 + 6 - 1 = 3$

$\sin \alpha = \frac{3}{\sqrt{(1 + 36 + 1)} \times \sqrt{(4 + 1 + 1)}} = \frac{3}{\sqrt{38} \times \sqrt{6}} = \frac{3}{2\sqrt{57}} = 0.19867...$

$\alpha = 11.459...°$

$\alpha = 11°$ (nearest degree)

(c) $\Pi$: $r \cdot (-2i + j + k) = (4i + 2j + k) \cdot (-2i + j + k)$

$r \cdot (-2i + j + k) = -8 + 2 + 1 = -5$

$A$: $(2i - 4j) \cdot (-2i + j + k) = -4 - 4 + 0 = -8$

$d = \frac{|-8 - (-5)|}{\sqrt{((-2)^2 + 1^2 + 1^2)}} = \frac{3}{\sqrt{6}} = \frac{\sqrt{6}}{2}$

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 5 continued**

Perpendicular distance from A to $\Pi = \frac{\sqrt{6}}{2}$

Leave blank

**Question 5 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 5 continued**

**(Total 10 marks)**

**Q5**

Leave blank

**6.** The matrix **M** is given by

$$\mathbf{M} = \begin{pmatrix} 3 & 0 & 1 \\ 1 & 2 & 2 \\ 4 & 0 & 3 \end{pmatrix}$$

(a) (i) Show that 5 is an eigenvalue of **M**.

(ii) Find the other two eigenvalues of **M**.

**(5)**

(b) Find an eigenvector corresponding to the eigenvalue 5

**(3)**

The transformation represented by the matrix **M** maps the straight line $l_1$ onto the straight line $l_2$

The equation of $l_1$ is $(\mathbf{r} - \mathbf{a}) \times \mathbf{b} = \mathbf{0}$ where $\mathbf{a} = 2\mathbf{i} + \mathbf{j} - 3\mathbf{k}$ and $\mathbf{b} = \mathbf{i} + 2\mathbf{j} - \mathbf{k}$

(c) Find an equation for the line $l_2$, giving your answer in the form $(\mathbf{r} - \mathbf{c}) \times \mathbf{d} = \mathbf{0}$ where **c** and **d** are constant vectors.

**(5)**

(a)(i) $\det(M - 5I) = \begin{vmatrix} -2 & 0 & 1 \\ 1 & -3 & 2 \\ 4 & 0 & -2 \end{vmatrix} = -2((-3)(-2) - 0) - 0 + 1(0 - (-3)(4))$

$= -12 + 12 = 0$, so 5 is an eigenvalue of M

(ii) $\det(M - \lambda I) = \begin{vmatrix} 3-\lambda & 0 & 1 \\ 1 & 2-\lambda & 2 \\ 4 & 0 & 3-\lambda \end{vmatrix} = 0$

$(3 - \lambda)(2 - \lambda)(3 - \lambda) - 4(2 - \lambda) = 0$

$(2 - \lambda)[(3 - \lambda)^2 - 4] = 0$

$\lambda^3 - 8\lambda^2 + 17\lambda - 10 = 0$

$(\lambda - 2)(\lambda - 5)(\lambda - 1) = 0$

Other eigenvalues: $\lambda = 1$ and $\lambda = 2$

(b) $\begin{pmatrix} 3 & 0 & 1 \\ 1 & 2 & 2 \\ 4 & 0 & 3 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = 5 \begin{pmatrix} x \\ y \\ z \end{pmatrix}$

$3x + z = 5x \Rightarrow z = 2x$

$x + 2y + 2z = 5y \Rightarrow x + 4x = 3y \Rightarrow 3y = 5x$

$4x + 3z = 5z \Rightarrow z = 2x$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 6 continued**

Let $x = 3$: eigenvector $\begin{pmatrix} 3 \\ 5 \\ 6 \end{pmatrix}$

(c) $l_1$ passes through $(2, 1, -3)$ with direction $i + 2j - k$

$$\begin{pmatrix} 3 & 0 & 1 \\ 1 & 2 & 2 \\ 4 & 0 & 3 \end{pmatrix}\begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix} = \begin{pmatrix} 6+0-3 \\ 2+2-6 \\ 8+0-9 \end{pmatrix} = \begin{pmatrix} 3 \\ -2 \\ -1 \end{pmatrix}$$

$$\begin{pmatrix} 3 & 0 & 1 \\ 1 & 2 & 2 \\ 4 & 0 & 3 \end{pmatrix}\begin{pmatrix} 1 \\ 2 \\ -1 \end{pmatrix} = \begin{pmatrix} 3+0-1 \\ 1+4-2 \\ 4+0-3 \end{pmatrix} = \begin{pmatrix} 2 \\ 3 \\ 1 \end{pmatrix}$$

$l_2$ passes through $(3, -2, -1)$ with direction $2i + 3j + k$

$l_2$: $(r - (3i - 2j - k)) \times (2i + 3j + k) = 0$





Leave blank

**Question 6 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 6 continued**

**(Total 13 marks)**

**Q6**

Leave blank

**7.** $$I_n = \int \cosh^n x \, dx \qquad n \geqslant 0$$

(a) Show that, for $n \geqslant 2$

$$nI_n = \sinh x \cosh^{n-1} x + (n-1) I_{n-2}$$

**(6)**

(b) Hence find

$$\int \cosh^4 x \, dx$$

**(4)**

(a) $I_n = \int \cosh^n x \, dx = \int \cosh x \cosh^{n-1} x \, dx$

$u = \cosh^{n-1} x \Rightarrow u' = (n-1)\cosh^{n-2} x \sinh x; \quad v' = \cosh x \Rightarrow v = \sinh x$

$I_n = \sinh x \cosh^{n-1} x - \int (n-1)\cosh^{n-2} x \sinh^2 x \, dx$

$= \sinh x \cosh^{n-1} x - (n-1) \int \cosh^{n-2} x (\cosh^2 x - 1) \, dx$

$= \sinh x \cosh^{n-1} x - (n-1) \int \cosh^n x \, dx + (n-1) \int \cosh^{n-2} x \, dx$

$I_n = \sinh x \cosh^{n-1} x - (n-1) I_n + (n-1) I_{n-2}$

$I_n + (n-1) I_n = \sinh x \cosh^{n-1} x + (n-1) I_{n-2}$

$nI_n = \sinh x \cosh^{n-1} x + (n-1) I_{n-2}$ as required

(b) $n = 4: \quad 4I_4 = \sinh x \cosh^3 x + 3I_2$

$n = 2: \quad 2I_2 = \sinh x \cosh x + I_0, \quad I_0 = \int 1 \, dx = x$

$I_2 = \frac{1}{2} \sinh x \cosh x + \frac{1}{2} x$

$4I_4 = \sinh x \cosh^3 x + \frac{3}{2} \sinh x \cosh x + \frac{3}{2} x$

$\int \cosh^4 x \, dx = \frac{1}{4} \sinh x \cosh^3 x + \frac{3}{8} \sinh x \cosh x + \frac{3}{8} x + c$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA



P 5 6 4 8 0 A 0 2 4 3 2
stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 7 continued**

Leave blank

**Question 7 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 7 continued**

**(Total 10 marks)**

**Q7**





stemup.co.uk

Leave blank

**8.** An ellipse has equation

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \qquad a > 0,\ b > 0$$

The line $l$ has equation $y = mx + c$ where $m < 0$ and $c > 0$

Given that $l$ is a tangent to the ellipse,

(a) show that $c^2 = b^2 + a^2m^2$

**(4)**

The tangent $l$ meets the positive $x$-axis at the point $A$ and the positive $y$-axis at the point $B$. The origin is $O$.

Given that $m$ varies,

(b) show that the minimum area of triangle $OAB$ is $ab$.

**(7)**

(a) $\frac{x^2}{a^2} + \frac{(mx + c)^2}{b^2} = 1$

$b^2x^2 + a^2(m^2x^2 + 2mcx + c^2) = a^2b^2$

$(b^2 + a^2m^2)x^2 + 2a^2mcx + a^2(c^2 - b^2) = 0$

$l$ is a tangent $\Rightarrow$ repeated root $\Rightarrow$ discriminant $= 0$

$(2a^2mc)^2 - 4(b^2 + a^2m^2)a^2(c^2 - b^2) = 0$

$4a^4m^2c^2 = 4a^2(b^2 + a^2m^2)(c^2 - b^2)$

$a^2m^2c^2 = b^2c^2 - b^4 + a^2m^2c^2 - a^2m^2b^2$

$0 = b^2(c^2 - b^2 - a^2m^2), \qquad b \neq 0$

$c^2 = b^2 + a^2m^2$ as required

(b) $y = 0 \Rightarrow x = -\frac{c}{m}, \quad x = 0 \Rightarrow y = c$

A is $(-\frac{c}{m}, 0)$, B is $(0, c)$ $\qquad (-\frac{c}{m} > 0$ as $m < 0, c > 0)$

Area $\Delta = \frac{1}{2} \times (-\frac{c}{m}) \times c = -\frac{c^2}{2m} = -\frac{b^2 + a^2m^2}{2m}$

$\Delta = -\frac{b^2}{2} m^{-1} - \frac{a^2}{2} m$

$\frac{d\Delta}{dm} = \frac{b^2}{2m^2} - \frac{a^2}{2} = 0 \Rightarrow m^2 = \frac{b^2}{a^2}$

$m < 0 \Rightarrow m = -\frac{b}{a}$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 8 continued**

$\frac{d^2\Delta}{dm^2} = -\frac{b^2}{m^3} > 0$ since $m < 0$, so this gives a minimum

Min area $= -\frac{b^2 + a^2(b^2/a^2)}{2(-b/a)} = \frac{2b^2}{2b/a} = ab$

Minimum area of triangle OAB is ab





stemup.co.uk

Leave blank

**Question 8 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA





stemup.co.uk

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

**Question 8 continued**

Leave blank

**Question 8 continued**

Q8

**(Total 11 marks)**

**TOTAL FOR PAPER: 75 MARKS**

**END**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA





stemup.co.uk